Available online at www.sciencedirect.com
SCIENCE DIRECT®
Futures 37 (2005) 605–613
FUTURES
www.elsevier.com/locate/futures

Knowledge, limits and boundaries

Paul Cilliers*

Department of Philosophy, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Available online 24 January 2005

Abstract

In this paper the underlying concern is the problem of knowledge. How do we understand the world, what is 'scientific' knowledge, and to what extent is this knowledge limited by the fact that the world in which we live is complex? The problems associated with the status of our knowledge of the world have been central to philosophy all along. Here I will focus on the way in which the acknowledgement of complexity transforms some of the traditional conceptions of (especially scientific) knowledge. I will also examine the notions of boundaries and limits, arguing that these notions are not problems we have to get out of the way, but that they are inevitable as soon as we start talking of 'knowledge'.

"There's danger at the edge of town" The Doors

1. Introduction[1]

I understand this special edition to be primarily concerned with the problem of knowledge. How do we understand the world, what is 'scientific' knowledge, and to what extent is this knowledge limited by the fact that the world in which we live is complex? The problems associated with the status of our knowledge of the world have been central to philosophy all along. Here I will focus on the way in which the acknowledgement of complexity transforms some of the traditional conceptions of (especially scientific) knowledge. I will also examine the notions of boundaries and limits, arguing that these

* Tel.: +27 21 808 2421; fax: +27 21 808 3556.
E-mail address: fpc@sun.ac.za.
[1] This paper is based on material used in Cilliers [2,3].

0016-3287/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.futures.2004.11.001

notions are not problems we have to get out of the way, but that they are inevitable as soon as we start talking of 'knowledge'.

2. The problem

As science confronted more and more complex problems, various manifestations of the problem of limits appeared: relativity theory introduced the speed of light as absolute limit, quantum theory made us aware of inescapable uncertainty, and Gödel and Turing brought us face to face with limits of deductive logic.

Influential as these ideas were, they are all still largely part of an attempt to describe the world in purely objective terms. The speed of light is a constant of nature; undecidability is an inevitable characteristic of formal systems. Limits, therefore, are natural things.

The perspective introduced by complexity is rather different. Here the argument is the following: a complex system is constituted through a large amount of non-linear interactions and cannot be separated from its environment. It is thus not possible (in practice or in principle, the argument goes), to give a complete, analytical and formal description of a complex system. We have to frame the system in a certain way when we want to describe it. There is, however, no 'pure' position outside the system we can assume in order to determine the parameters of this frame (unless we are dealing with well-defined and closed systems which are normally at most complicated, and not complex). The result is that we cannot determine the limits of our description objectively. Limits are determined by strategic considerations. Even though this does not necessarily mean that limits are arbitrary, it does mean that considerations of power and expediency affect the way in which we understand the world.

These ideas are disconcerting for those believing in science as something that has to maintain some form of objectivity. It seems to open the door to a relativism that would destroy the notion of 'scientific knowledge'. In what follows I will try to take the argument from complexity seriously, but in such a way that we do not fall prey to relativism. It will, however, necessitate a re-examination of what we understand as 'knowledge'.

3. The problem of knowledge

3.1. What qualifies as knowledge?

The immense usefulness of mathematics has led to an understanding of scientific knowledge that is linked to formal models: one has 'knowledge' of a subject to the extent that it can be described in terms of a set of (objective) rules. The knowledge is contained in an algorithm, and the complexity of the knowledge is equivalent to the length of the algorithm. This has resulted—according to, e.g. Robert Rosen [11]—in a shift towards *methodology*, and away from the *content* of scientific knowledge.

I think it is important to ask if one can talk of 'formal *knowledge*' at all. Perhaps one should reserve the notion 'knowledge' for something that has *meaning*, that is meaningful to a human subject (I will return to this below). Knowledge would then refer to something

with empirical content, not an abstract algorithm. The notion of empirical content is also important if we want make some ontological claims beyond a pure and formal, Platonic kind of epistemology. The issue is interesting particularly because we can do things technologically that we do not understand. For example, I can build a neural network that can perform some kind of pattern recognition, like recognising faces. I know how the network works, but I do not know how it solves the problem. Can I now claim that I 'know' how to recognise faces? I do not think so. This would be to confuse data with knowledge. Perhaps 'knowledge' is a concept used with too much ease, as in 'knowledge management'. We cannot 'know' a complex thing in all its complexity, we reduce the complexity in order to be able to say something about it within the finite means of our comprehension. Knowledge and data-reduction are intertwined. We can have knowledge because we draw boundaries. Let us examine these concepts in a little more detail.

The issues around knowledge—*what* can we know about the world, *how* do we know it, what is the *status* of our experiences—have been central to philosophical reflection for ages. Answers to these questions, admittedly oversimplified here, have traditionally taken one of two forms. On the one hand there is the belief that the world can be made rationally transparent, that with enough hard work knowledge about the world can be made objective. Thinkers like Descartes and Habermas are often framed as being responsible for this kind of attitude, and it goes under numerous names including positivism, modernism, objectivism, rationalism and epistemological fundamentalism. On the other hand, there is the belief that knowledge is only possible from a personal or cultural-specific perspective, and that it can therefore never be objective or universal. This position is ascribed, correctly or not, to numerous thinkers in the more recent past like Kuhn, Rorty and Derrida, and its many names include relativism, idealism, post-modernism, perspectivism and flapdoodle.

Relativism is not a position that can be maintained consistently,[2] and of course the thinkers mentioned above have far more sophisticated positions than portrayed in this bipolar caricature. There are also recent thinkers who attempt to move beyond the fundamentalist/relativist dichotomy, but it seems to me that when it comes to the technological applications of theories of knowledge, there is an implicit reversion to one of these traditional positions. For those who want to computerise knowledge, knowledge has to be objective. It must be possible to gather, store and manipulate knowledge without the intervention of a subject. The critics of formalised knowledge, on the other hand, usually fall back on arguments based on subjective or culture-specific perspectives to show that it is not possible, that we cannot talk about knowledge independently of the knowing subject.

[2] If relativism is maintained consistently, it becomes an absolute position. From this one can see that a relativist is nothing else but a disappointed fundamentalist. However, this should not lead one to conclude that everything that is called post-modern leads to this weak position. Lyotard's seminal work, The Postmodern Condition [8], is subtitled A Report on Knowledge. He is primarily concerned with the structure and form of different kinds of knowledge, not with relativism. An informed reading of Derrida will also show that deconstruction does not imply relativism at all. For a penetrating philosophical study of the problem, see Against Relativism [10].

4. Complexity and understanding

An understanding of knowledge as constituted within a complex system of interactions[3] would, on the one hand, deny that knowledge can be seen as atomised 'facts' that have objective meaning. Knowledge comes to be in a dynamic network of interactions, a network that does not have distinctive borders. On the other hand, this perspective would also deny that knowledge is something purely subjective, mainly because one cannot conceive of the subject as something *prior* to the 'network of knowledge', but rather as something constituted *within* that network. The argument from complexity thus wants to move beyond the objective/subjective dichotomy. The dialectical relationship between knowledge and the system within which it is constituted has to be acknowledged. The two do not exist independently, thus making it impossible to first sort out the system (or context), and then to identify the knowledge within the system. This co-determination also means that knowledge and the system within which it is constituted is in constant transformation. What appears to be uncontroversial at one point may not remain so for long.

The points made above are just a restatement of the claim that complex systems have a history, and that they cannot be conceived of without taking their context into account. The burning question at this stage is whether it is possible to *do* that formally or computationally. Can we incorporate the context and the history of a system into its description, thereby making it possible to extract knowledge from it? This is certainly possible (and very useful) in the case of relatively simple systems, but with complex systems there are a number of problems. These problems are, at least to my mind, not of a metaphysical, but of a practical nature.

The first problem has to do with the non-linear nature of the interactions in a complex system. From this it can be argued [1:9–10] that complexity is incompressible. There is no accurate (or rather, perfect) representation of the system, which is simpler than the system itself. In building representations of open systems, we are forced to leave things out, and since the effects of these omissions are non-linear, we cannot predict their magnitude. This is not an argument claiming that reasonable representations should not be constructed, but rather an argument that the unavoidable limitations of the representations should be acknowledged.

This problem—which can be called the problem of boundaries—is compounded by the dynamic nature of the interactions in a complex system. The system is constituted by rich interaction, but since there are an abundance of direct and indirect feedback paths, the interactions are constantly changing. Any activity in the system reverberates throughout the system, and can have effects that are very difficult to predict—once again as a result of the large amount of non-linear interactions. I do not claim that these dynamics cannot be modelled. It could be possible that richly connected network models can be constructed. However, as soon as these networks become sizeable, they become extremely difficult to train. It also becomes rather hard to figure out what is actually happening in them. This is

[3] Complex systems are discussed in detail in Cilliers [1].

no surprise if one grants the argument that a model of a complex system will have to be as complex as the system itself. Reduction of complexity always leads to distortion.

What are the implications of the arguments from complexity for our understanding of the distinction between data and knowledge? In the first place it problematises any notion that data can be transformed into knowledge through a pure, mechanical and objective process. It, however, also problematises any notion that would see the two as totally different things. There are facts that exist independently of the observer of those facts, but the facts do not have their meaning written on their faces. Meaning only comes to be in the process of interaction. Knowledge is interpreted data. This leads us to the next big question: what is involved in interpretation, and who (or what) can do it?

5. Knowledge and the subject

Before talking about specific forms of knowledge (scientific, algorithmic, knowledge which can be managed) we have to deal with the question of how the human *subject* deals with knowledge in the first place. Given the complexities of that which we wish or have to know, how does the subject come to forms of understanding, and what is the status of knowledge as understood by a specific subject? This issue has been pursued by many philosophers, especially in the discipline known as hermeneutics. However, I am not aware that this has been done in any depth in the context of complexity theory.[4] How does one perceive of the subject as something that is not atomistically self-contained, but is constituted through dynamic interaction? Moreover, what is the relationship between such a subject and its understanding of the world? A deeper understanding of what knowledge is, and how to 'manage' it, will depend heavily on a better understanding of the subject. This is a field of study with lots of opportunities.

Apart from calling for renewed effort in this field, I only want to make one important remark. It seems that the development of the subject from something totally incapable of dealing with the world on its own into something that can begin to interpret—and change—its environment is a rather lengthy process. Childhood and adolescence are necessary phases (sometimes the only phases) in human development. In dealing with the complexities of the world there seems to be no substitute for experience (and education). This would lead one to conclude that when we attempt to automate understanding, a learning process will also be inevitable. This argument leads one to support computing techniques, which incorporate learning (like neural networks) rather than techniques which attempt to abstract the essence of certain facts and manipulate them in terms of purely logical principles. Attempts to develop a better understanding of the subject will not only be helpful in building machines that can manage knowledge, it will also help humans to better understand what they do themselves. We should not allow that the importance of

[4] An important contribution was made by reinterpreting action theory from the perspective of complexity (Juarrero [5]). Some preliminary remarks, more specifically on complexity and the subject, are made in Cilliers and De Villiers [4].

machines (read computers) in our world leads to a machine-like understanding of what it is to be human.

Knowledge as something that has meaning for a subject will always be contextualised. It will form part of our experience of the world, and will therefore be influenced by relationships of power. Knowledge cannot be symmetrical, pure, complete or ahistorical. It is always bounded. The status and function of boundaries, when dealing with complex systems, therefore need closer analysis.

6. The nature of boundaries

In order to be recognisable as such, a system must be bounded in some way. However, as soon as one tries to be specific about the boundaries of a system, a number of difficulties become apparent. For example, it seems uncontroversial to claim that one has to be able to recognise what belongs to a specific system, and what does not. But complex systems are open systems where the relationships amongst the components of the system are usually more important than the components themselves. Since there are also relationships with the environment, specifying clearly where a boundary could be, is not obvious.

One way of dealing with the problem of boundaries is to introduce the notion of 'operational closure'.[5] For a system to maintain its identity, it must reproduce itself (internally). These arguments often follow from the work by Maturana and Varela on autopoiesis. Zeleny (in Khalil and Boulding [6:123]) defines an autopoietic system as

> "… a system that is generated through a closed organisation of production processes such that the same organisation of processes is regenerated through the interaction of its own products (components), and a boundary emerges as a result of the same constitutive processes."

When dealing with complex systems in an 'operational' way, there is nothing wrong with this approach. One should be careful, however, not to overemphasise the closure of the boundary. The boundary of a complex system is not clearly defined once it has 'emerged'. Boundaries are simultaneously a function of the activity of the system itself, and a product of the strategy of description involved. In other words, we frame the system by describing it in a certain way (for a certain reason), but we are constrained in where the frame can be drawn. The boundary of the system is therefore neither purely a function of our description, nor is it a purely natural thing. We can never be sure that we have 'found' or 'defined' it clearly, and therefore the closure of the system is not something that can be described objectively. An overemphasis on closure will also lead to an understanding of the system that may underplay the role of the environment. However, we can certainly not do away with the notion of a boundary.

Our understanding of boundaries can be given a little more content by considering the following two issues. The first concerns the 'nature' of boundaries. We often fall into the

[5] The work of Niklas Luhmann provides a good example of this approach. (For a monograph in English, see Luhmann [7]).

trap of thinking of a boundary as something that separates one thing from another. We should rather think of a boundary as something that *constitutes* that which is bounded. This shift will help us to see the boundary as something enabling, rather than as confining. To quote Zeleny [6] again:

> "All social systems, and thus all living systems, create, maintain, and degrade their own boundaries. These boundaries do not separate but intimately connect the system with its environment. They do not have to be just physical or topological, but are primarily functional, behavioral, and communicational. They are not 'perimeters' but functional constitutive components of a given system."

As an example of this logic, think of the eardrum. It forms the boundary between the inner and the outer ear, but at the same time it exists in order to let the sound waves through. As a matter of fact, if it was not there, the sound waves would not be able to get through at all! If the boundary is seen as an interface participating in constituting the system, we will be more concerned with the margins of the system, and perhaps less with what appears to be central.[6]

A second boundary issue concerns the 'place' of the boundary. The propensity we have towards visual metaphors inclines us to think in spatial terms. A system is, therefore, often visualised as something contiguous in space. This tendency is reinforced by the prevalence of biological examples of complex systems. We think of systems in an 'organistic' way. Social systems are obviously not limited in the same way. Parts of the system may exist in totally different spatial locations. The connections between different components could be seen as virtual, and therefore the system itself may exist in a virtual space. This much should be self-evident to most inhabitants of the global village, but there are two important implications to drawn from this. The first is that non-contiguous sub-systems could be part of many different systems simultaneously. This would mean that different systems interpenetrate each other, that they share internal organs. How does one talk of the boundary of the system under these conditions? A second implication of letting go of a spatial understanding of boundaries would be that in a critically organised system we are never far away from the boundary. If the components of the system are richly interconnected, there will always be a short route from any component to the 'outside' of the system. There is thus no safe 'inside' of the system, the boundary is folded in, or perhaps, the system consists of boundaries only. Everything is always interacting and interfacing with others and with the environment; the notions of 'inside' and 'outside' are never simple or uncontested.

In accepting the complexity of the boundaries of complex systems, we are committed to be critical about how we use the notion since it affects our understanding of such systems, and influences the way in which we deal with them. The notion of 'boundary critique' is not a new one (see Midgley et al. [9]), but in this critique we have to keep the enabling nature of boundaries in mind, whilst simultaneously trying to displace (deconstruct) them.

---

[6] Although it will not be elaborated on in this text, a number of the ideas presented have a close affinity to arguments from deconstruction. For more detail, see Cilliers [1], especially chapter three.

The argument for an understanding of boundaries and constraints as being enabling, and the observation that in a complex system one is never far away from a boundary,[7] have certain of implications. One can, for example, deal with a system as if it is a pre-given and objectively defined entity. Then the boundaries will be clear to the extent that one could say that they are 'natural'. There are systems like this, but they are usually neither complex nor interesting—systems like machines. If one acknowledges the complexity of a system, it becomes more difficult to talk about 'natural' boundaries. Boundaries are still required if we want to talk about complex systems in a meaningful way—they are in fact *necessary*, as argued above—but there are strategic considerations at stake when drawing them. These considerations may include subjective, or intersubjective components, but this does not mean that they are arbitrary. A complex system has structure and patterns that would render some descriptions more meaningful than others, but the point is that we do not have an *a priori* decision procedure for determining when we are dealing with something 'more meaningful'. The contingent and historic nature of complex systems entails that our understanding of the system will have to be continually revised; the frames of our models will have to change. The boundaries of complex systems cannot be identified objectively, finally and completely.

This supports the argument that our knowledge of complex systems cannot be reduced to formal algorithms, but has to incorporate considerations of what the knowledge is for. The criteria used to evaluate the knowledge are not independent things; they co-determine the nature of the knowledge (see Rosen [11]). Knowledge cannot be abstract and complete—we cannot 'know' something like that. For us to have knowledge about something, it has to be limited.

I want to stress that this does not imply a subjective relativism. It merely acknowledges the inevitability of choice when trying to understand a complex system, and it is exactly at this point that we encounter the ethical domain.

7. The challenge of the limit

In Nicholas Roeg's remarkably visionary film *The Man Who Fell to Earth* (1976), an alien using the name Thomas Jerome Newton (superbly played by David Bowie), tries to understand human culture by watching television—usually a whole bunch of screens at the same time. Despite the immense amount of data available to him, he is not able to understand what is going on directly. It is only through the actual *experience* of political complexities, as they unfold in time, that he begins to understand. By then he is doomed to remain earthbound. It is only from a situated position that we can have knowledge, never from an abstract or divine one—and the computer will not be able to replace God in this argument either.

It should be stressed, however, that when we conclude that limits are necessary for the generation of meaning, then there is no need to feel despondent when we encounter them. They form an integral part of the development and transformation of knowledge. The fact

[7] For the sake of clarity, I propose that we talk about the limits of knowledge and of the boundaries of systems.

that it becomes a little more difficult to talk about 'objective' knowledge should also not lead to despair, but to humility. The issues in need of urgent attention seem, to me at least, to be the following:

- Developing the notion of 'scientific' knowledge in order to go beyond an abstract objectivity without falling prey to relativism.
- Elaborating the ethical considerations inherent to all forms of knowledge.

Complexity theory may turn out to be central to these explorations. It may also be just what we need in order to start building bridges between the 'two cultures'.

References

[1] P. Cilliers, Complexity and Postmodernism. Understanding Complex Systems, Routledge, London, 1998.
[2] P. Cilliers, Knowledge, complexity and understanding, Emergence 2 (4) (2000) 7–13.
[3] P. Cilliers, Boundaries, hierarchies and networks in complex systems, International Journal of Innovation Management 5 (2) (2001) 135–147.
[4] P. Cilliers, T. de Villiers, The complex 'I' in: W. Wheeler (Ed.), The Political Subject, Lawrence and Wishart, London, 2000, pp. 226–245.
[5] A. Juarrero, Dynamics in Action. Intentional Behaviour as a Complex System, MIT Press, Cambridge, MA, 1999.
[6] E.L. Khalil, K.E. Boulding (Eds.), Evolution, Order and Complexity, Routledge, London, 1996, p. 133. Zeleny.
[7] N. Luhmann, Ecological Communication, University of Chicago Press, Chicago, 1989.
[8] J.F. Lyotard, The Postmodern Condition: A Report on Knowledge, Manchester University Press, Manchester, 1984.
[9] G. Midgley, I. Munlo, M. Brown, The theory and practice of boundary critique: developing housing services for older people, Journal of the Operational Research Society 49 (1998) 467–478.
[10] C. Norris, Against Relativism. Philosophy of Science, Deconstruction and Critical Theory, Blackwell Publishers, Oxford, 1997.
[11] R. Rosen, On the limitations of scientific knowledge in: J.L. Casti, A. Karlqvist (Eds.), Boundaries and Barriers. On the Limitations of Scientific Knowledge, Addison Wesley, Reading, MA, 1996, pp. 199–214.